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ORIGINAL

PROVISIONAL SPECIFICATION

INDUSTRIAL PRESS SAFETY SYSTEM

The invention is described in the following statement:

INDUSTRIAL PRESS SAFETY SYSTEM

The present invention is generally directed to safety systems used in industrial applications, and in particular to safety systems for use on industrial presses such as a press brake.

5 The dangers associated with the operation of industrial presses has necessitated the development of various safety arrangements to protect workers using such presses. Safety light curtain systems are commonly used to provide a plurality of parallel infrared (IR) light beams as a "barrier" for the press. The breaking of any of the IR light beams by the operator of the press results in the
10 stopping of the operation of the press. These safety light curtains must however be located a significant distance in front of the press to operate with any effectiveness. This is because of the degree of dispersion of the IR light beams over the extended distances limits the accuracy and speed of operation of such light curtains.

 In British Patent No. 1307078, there is described a light curtain guard for a
15 press brake of the kind having an upward stroking ram. The light curtain guard is also formed by a series of parallel light beams, the main difference being that the light curtain guard is supported on and moveable with the upward stroking ram.

 The use of light curtains is however not always possible where they can interfere with the use of the press in manufacturing operations. Therefore, in
20 Australian Patent No. 667057, there is described a safety apparatus for use on a press brake of the kind having a moving blade and stationary platform. The safety apparatus is mounted on the moving blade and emits at least one beam of light in close relation to the leading edge of the moving blade. The light beam can be either an IR or a laser beam. A laser beam is preferable because of the negligible
25 dispersion of such a beam leading to greater accuracy in the operation of the apparatus.

 In all of the above-described systems the breaking of the light beam causes the press to stop or prevents the press from operating.

 The above noted systems however have certain disadvantages. Firstly
30 because all of the above arrangements rely on a series of parallel IR or laser beams to provide a barrier, there is always the possibility of the safety light curtain being

inadvertently bypassed by an object passing between adjacent parallel light beams and not breaking any of the light beams. The safety light curtain is therefore ineffectual under these circumstances.

Also, in the case of arrangements using laser beams, vibrations can seriously distort the path of the laser beam causing disruptions and inaccuracies in the operation of such arrangements. Although the use of software "filtering" or compensation can be used to minimise the effect of vibrations as for example shown in International Application No. PCT/AU97/00005, this results in an increase in the delay between the breaking of the light beam and the subsequent actuation of the safety system to stop the press. Such delays should preferably be minimised as far as possible, and preferably eliminated.

It is therefore an object of the present invention to provide a safety system for an industrial press that overcomes at least one of the disadvantages associated with the prior art.

With this in mind, the present invention provides a safety system for an industrial press having a moveable section, the safety means including:
a laser emitting means for emitting a continuous planar laser beam having a generally constant lateral width;
a light receiving means for receiving the laser beam and for detecting when an object intersects the laser beam; and
a control means for stopping or preventing movement of the moveable section of the press when the receiving means detects that the laser beam has intersected an object.

The use of a continuous planar laser beam having a generally constant lateral width means that the laser beam can cover a relatively wide area when compared with a conventional laser beam while at the same time ensuring that there are no "spaces" through which an object can pass without detection.

The industrial press can for example be a press brake having a blade and an anvil moveable relative to each other. The laser beam may be emitted immediately adjacent the leading edge of the blade. According to one possible arrangement, the plane of the laser beam may be horizontal and located between the blade and anvil

the laser emitting means and the light receiving means may be mountable on the blade, and may move with the blade if that part is the moveable section of the press brake. This ensures that the introduction of an object close enough to the blade to intersect the laser beam will stop or prevent the operation of the press. Alternative orientations of the laser beam are however also envisaged. For example, the laser beam can be emitted in front of the blade with the plane of the laser beam being generally vertical. Alternatively, laser beams can be emitted both in front of and under the cutting blade. This provides an "L" shaped configuration of planar laser beams.

10 The laser emitting means may include a laser emitter, for example a laser diode for emitting a laser beam, and a lens assembly for varying the configuration of the laser beam emitted from the laser diode. Laser beams emitted by such laser emitters are typically circular in cross section. The lenses assembly converts this laser beam into a laser beam of generally planar shape and having a generally
15 constant lateral width. It should be noted that some dispersion of the laser beam may occur the further away a point on the laser beam is from the laser emitter. This dispersion is however relatively insignificant within the range of distances that the laser beam must be emitted over, typically between 2 to 12 metres.

The lenses assembly may include a cylindrical prism for initially expanding
20 the laser beam into laser beam having a planar fan shaped configuration. The lenses assembly may also include a converging lenses for refocusing the fan shaped laser beam to a planar laser beam having a generally constant lateral width. The original laser beam emitted from the laser emitter has virtually parallel "lines of light". The light intensity when measured across the lateral width of the planar laser
25 beam can however vary. This is due to the refractive effect of the lenses on the laser beam which can cause a deflection in the lines of light within the laser beam resulting in an overlapping of the lines of light therein. The "shadow" produced by an object intersecting the laser beam may therefore not be detected by the receiving means as the lines of light passing the object can overlap thereby obscuring any
30 shadow produced by the object. A correcting lenses may therefore need be provided after the converging lenses to straighten the lines of light of the laser beam

refocused through the converging lenses. The correcting means may, for example, be in the form of a lenticular lenses having a plurality of lenses sections which respectively straighten the portion of the laser beam passing therethrough. Alternatively, a series of separate parallel lenses may be placed side to side in front of the converging lenses, each lenses correcting a portion of the laser beam. This will ensure that the lines of light of the laser beam are generally parallel, and that an object intersecting the corrected laser beam will cast a clear shadow on the receiving means.

The receiving means may include a plurality of electronic light receivers aligned on along a common axis. Each light receiver may be located at the end of a light receiving passage to prevent other light, eg. reflected light, from effecting the reading obtained from the light receiver. These light receiving passages may be configured to only see light emitted by the laser beam. The light receiving passage may be in the form of a cylindrical bore provided within a solid block, the bore extending most of the way or completely through the block. A plurality of said light receiving passages may be aligned in a parallel relation through the solid block. The light receivers may be provided at the end of each passage, the opposing end of the passages being exposed to and aligned with the lateral extent of the planar laser beam.

Alternatively, the receiving means may include a focussing arrangement, for example a "cylindrical" lens in front of the light receivers. Each light receiver may be located at the end of a light receiving passage. The passage may be provided by a box shaped enclosure separated into separate parallel passages by dividing walls. The cylindrical lens may be an elongate lens having a relatively uniform cross-section along its length. One side of the lens may have a constant radius of curvature, while the other side of the lens may be generally flat. Such a lens focuses in one plane only and has a fixed focal point. It is however also envisaged that a plurality of lenses may be provided in front of the light receivers. The above described arrangement helps to ensure that the laser beam is focussed on to the light receivers, even where there is some displacement of the laser beams.

All the light receivers may be aligned with and exposed to the same continuous planar laser beam during operation of the safety system according to the present invention. Therefore any vibration of the press which results in lateral deflection of the laser beam within a predetermined range should not effect the operation of the receiving means. This is because all the light receivers will still be exposed to the same laser beam even when there is a lateral deflection of the laser beam. The safety system according to the present invention can therefore be relatively insensitive to vibration of the press where the vibrations primarily result in lateral deflection of the laser beam.

As it can therefore be possible to avoid the need for any software compensation for the vibration effect on the laser beam, and any intersection by an object of the laser beam can result in a direct signal being provided to the control means to stop or prevent movement of the press thereby eliminating or minimising any delay from the breaking of the laser beam to the stopping of the press. The control means can be in the form of an electronic control unit which receives signals from the light receivers and controls the operation of the press.

To improve the operational control of the safety system, the light receivers may be grouped into separate sections. Each section of light receivers may provide their own separate control signal. The light receivers can, for example, be grouped into a front section, a mid section and a rear section.

Both the laser emitting means and the light receiving means may be respectively mounted on supports on opposing sides of the moveable section of the press. The supports may be respectively adjustable to allow the alignment and position of the laser emitting means to be adjusted. For example, where the moveable section is a cutting blade, blades of different heights can be used, and the position of the laser emitting means and light receiving means will need to be adjusted. Alternatively, only the laser emitting means need be adjusted, the light receiving means remaining fixed. This is, for example, possible where the light receiving means includes a said focussing arrangement in front of the light receivers.

It will be convenient to further describe the invention by reference to the accompanying drawings which illustrate a possible arrangement of the present

the present invention is not to be understood as superseding the generality of the proceeding description of the invention.

In the drawings:

5 Figure 1 is a schematic view of a laser diode and lenses assembly according to the present invention;

Figure 2 is a plan view of a continuous planar laser beam emitted by the safety system according to the present invention;

10 Figure 3 is a cross-sectional view of the continuous planar laser beam emitted by the safety system;

Figure 4 is a plan view of a first possible arrangement of the light receiving means according to the present invention;

Figure 5 is an end view of the light receiver assembly of Figure 4;

15 Figure 6 is a side view of a second possible arrangement of the light receiving means according to the present invention;

Figure 7 is a perspective view of the cylindrical lens of Figure 7.

Figure 8 is a cross-sectional detail view of an industrial press showing the location of the laser beam; and

20 Figure 9 is a schematic view of the safety system mounted on an industrial press.

Referring initially to Figure 1, the industrial press safety system according to the present invention includes a laser emitting means 1 having a laser emitter 2, for example a laser diode, and a lenses assembly 8 for converting the laser beam 3 emitted from the laser emitter 2 into a continuous planar laser beam 9.

25 Figure 2 is a cross section of the continuous laser beam 9 emitted by the laser emitting means 1. This laser beam 9 has a generally constant lateral width W along its' elongate extent. Furthermore, the continuous planar laser beam 9 has a generally constant thickness T . According to one possible configuration of the present invention, the laser beam 9 can have a lateral width of about 45mm on average and a thickness of 8 mm on average. The angle of dispersion of the laser beam 9 is preferably equal to or less than 0.1%. It should be appreciated that

30

alternative configurations are possible in dependence on the application of the safety system.

Returning to Figure 1, the lenses assembly 8 includes a cylindrical prism 5 for initially expanding the laser beam 3 into a planar fan shaped beam 6. This planar fan shaped beam 6 then passes through a converging lens 7 for refocusing the fan shaped beam 6 into the planar laser beam 9 having a generally constant lateral width. It has been found that the light intensity when measured across the lateral width of the planar laser beam 9 will vary across that lateral width. This variation of light intensity is not normally visible to the eye, Figure 2 nevertheless schematically shows the light intensity variation, with areas 10 of increased light intensity distributed across the lateral extend of the last beam 9. It is considered that this is due to the refractive effect of the lenses 5, 7 which causes the parallel "lines of light" of the initial laser beam 3 to be deflected such that they are no longer parallel in the planar laser beam 9 emitted from the converging lens 7. A correcting lens 11 is therefore placed in front of the converging lens 7 to straighten the lines of light of the laser beam 9 so that they are generally parallel. The correcting lens 11 can be in the form of a lenticular lens having a plurality of lenses sections which respectively straighten the portion of the laser beam passing through that section. It is however also envisaged that a plurality of parallel lenses may be placed side by side in front of the converging lens 7, each lens correcting a respective portion of the laser beam 9.

Figure 3 helps to illustrate better the effect of not correcting the lines of light schematically shown as lines 15 in Figure 3. Where the planar laser beam 9 is left uncorrected from the converging lens 7, this results in an "overlapping" of the lines of light 15. By comparison, in the initial laser beam 3 from the laser emitter 2, the lines of light would be parallel, a typical characteristic of laser beam 5. Therefore, when an object intersects the planar laser beam 9, the overlapping of the lines of light 15 obliterates any shadow cast by the object 20. Therefore, the receiving means 22 will not detect any significant change in the light intensity of the planar laser beam 9 received by the light receiving means 22. The deflection of the lines of light 15 is typically less than 1° . Nevertheless, because of the long transmission distances, the

non-parallel nature of the uncorrected planar laser beam 9 will have a significant effect on the operation of the safety system.

Figure 4 shows in detail the construction of the light receiving means 22. This light receiving means 22 includes a plurality of electronic light receivers 26 aligned along a straight line. To eliminate the effect of light other than that received from the planar laser beam 9, each light receiver 26 is placed at the end of an elongate cylindrical passage 24 provided within a solid block 23. The light receiving means 22 further includes a base plate 27 for supporting the light receivers 26 and a front transparent cover 25 for covering the inlet opening of the cylindrical passages 24.

Figure 5 is an end view of the light receiving means 22 showing the aligned cylindrical passages 24 covered by the transparent cover 25. The planar laser beam 9 is simultaneously received by all of the light receivers 26, the area of the laser beam shining on the light receiving means 22 being shown in dotted lines 30. It can be seen that any lateral movement of the laser beam 9 due to vibration of the industrial press will not normally effect the operation of the safety system, with the laser beam 9 still being received by all of the light receivers 26 unless it is bent more than the distance X as shown in Figure 5. Most of the vibration within industrial presses such as a press brake result, in side to side motion. Therefore, the effect of vibrating on the laser beam 9 is minimised by aligning the plane of the laser beam 9 horizontally. It is therefore generally not necessary to provide any software correction for the signals produced by the light receivers 26 due to the effect of vibration on the laser beam 9.

An alternative possible arrangement of the light receiving means 22 of present invention is shown in Figure 6. Features which correspond to the arrangement shown in Figures 4 and 5 are designated with the same reference numeral. The light receivers 26 are located in the rear of an enclosure 38 and a "cylindrical" lens 37 is located in front of the light receivers 26 and extending in front of all the light receivers 26. The cylindrical lens 37, which is shown in perspective in Figure 7 has a forward side 39 with a constant radius of curvature. The rear side 40 of the lens 37 is generally flat. The cross-section of the lens 37 is generally constant along its length. In practice, the lens 37 is located in front of all the light receivers 26

so that the curve of the forward side of the lens 37 is opening in a vertical plane. Such a lens 37 is typically about 50 mm in height. A series of parallel and generally vertical dividing walls 36 are provided with the enclosure 38 to separate the enclosure 38 into a series of parallel light receiving passages 24, with a light receiver 26 being provided at the end of each passage 24.

Having such a cylindrical lens 37 ensures that whenever the laser beam 9 hits the lens 37 in the vertical plane, the light is focussed back to the light receivers 26 in that one plane. In other words, the lens 37 focuses light in one plane only. Such lens 37 also have a fixed focal point. This arrangement also ensures that the laser beam 9 will only be directed to the light receivers 26 if the beam 9 is horizontal (ie perpendicular) to the lens 37. The lens may allow a tolerance from the horizontal plane of typically about 1° , although this tolerance may be adjusted. This means that the light receivers 26 will only accept the laser beam 9 if it is running parallel to the component of the press being controlled, for example a movable blade 30 as shown in Figure 8. The dividing walls 36 within the enclosure 38 act to ensure that the light is coming straight to the light receivers 26 within said tolerance in this horizontal plane.

It is, however, also envisaged that a plurality of separate lenses be provided in front of the high receivers 26, with each lens focussing a respective section of the light beams. In this arrangement, the lenses could be of the more conventional circular type.

Figure 6 shows in dotted lines other positions of the leading edge of the blade 30 where different blades 30 are used. The laser beam 9 must therefore be repositioned for each different blade 30 as shown in Figure 6. The use of such a cylindrical lens 37 therefore allows the laser beam 9 to be at different heights due to differences in the depth of the blade 30 while still allowing the laser beam 9 to be focussed to the light receivers 26.

The light receivers 26 are positioned close together to thereby allow the laser beam 9 to be received across the width of the field of that laser beam 9. These light receivers 26 can be grouped to receive different segments of the beam 9, eg front section, mid section and rear section. This is so that, if required, an intersection of

The intersection of the laser beam 9 with the material can be responded to in different ways. For example, the intersection of the front section can result in the stopping and "jump back" of the movable blade 30. Intersection of the mid section of the laser beam 9 is used to trigger a "mute point" setting as well as provide a stop and jump back response of the blade 30. The mute point is the point beyond which the blade 30 will travel even if there is an intersection of the laser beam 9. Normally the laser beam 9 is triggered a short distance (typically approximately 4 mm) before it reaches the surface of the material to be bent and muted (ie. desensitized) to allow the bending process. It is considered that, at this distance, the smallest obstruction (ie a finger) could not be present. Finally, intersection of the rear section of the laser beam 9 will stop the blade 30, but without any jump back thereof. Also when switched into a special mode of operation, this rear section can be muted a few millimetres away from the material being bent. Therefore, if a back gauge 50, a standard apparatus on many press brakes, is brought in close to the blade 30 to do very short bends so that it is close enough to intrude onto the rear section of the laser beam 9, the back gauge 50 will not interrupt the bending process (see Figure 8).

The safety system according to the present invention may also provide other responses, for example, when the press is required to manufacture a box or tray where the sides thereof may be upstanding and may therefore intersect the laser beam 9 as the blade comes down. Therefore, at a "tray mode" of operation, when laser beam front section only is interrupted the first time, the blade 30 stops. If all the other sections of the laser beam 9 are clear, then the safety system allows a closing movement of the blade 30 after foot switch operated under this tray mode. This is to allow the sides of a tray or box to interrupt the front section of the laser beam 9 while still allowing the blade 30 to continue to move.

The rear section of the laser beam 9 may also need to be "muted" to allow the end wall of the tray to be formed. Therefore, the blade 30 will initially stop when the rear section is intercepted, but will continue following the pressing of the foot switch. This muting of the rear section of the laser beam 9 early, is considered safe because:

1. The rear of the press is far less likely to be accessed by the operator (and assistants) in normal working conditions; and
2. To help compensate (in this special mode only) the blade 30 stops at the mute point and needs a further foot switch application for the closing operation. This also ensures the operator knows he is in this special mode.

Figure 8 is a schematic cross sectional view showing the position of the planar laser beam 9 relative to the blade 30 and anvil 35 of a press brake. The planar laser beam 9 is located closely adjacent to the leading edge 32 of the blade 30, the plane of the laser beam 9 being generally horizontal. The laser emitting means 1 and light receiving means 22 can be mounted on the blade 30 (see Figure 9) or on the support structure (not shown) for the blade 30. Therefore, where the press brake is of the type having a moveable blade 30, the safety system will move together with the blade 30. Also shown is the movable back gauge 50 previously referred to.

Figure 9 shows the laser emitting means 1 and light receiving means 22 supported on brackets 45, 46, on the blade 30 of a press brake.

The laser beam 9 is typically set at a distance in the press of 8 mm between the leading edge of the blade 30 and the centre line of the light beam 9. There is some tolerance allowed but essentially this distance must be equal to or greater than the stopping distance of the blade 30 after it has a stop signal.

The emitting means 1 and light receiving means 22 can be mounted on adjustable brackets 45, 46, so they can be accurately adjusted to this distance whenever the blade 30 is changed for different bending processes. (The vertical depth of these blades 30 can often vary.) The adjusting brackets 45, 46, are refined to make these adjustments relatively easy but due to the accuracy needed with laser beams 9, it does need some work by the operator to get both ends aligned properly.

The press will never operate until both ends are aligned and the light receiving means 22 is receiving from the laser emitting means 1.

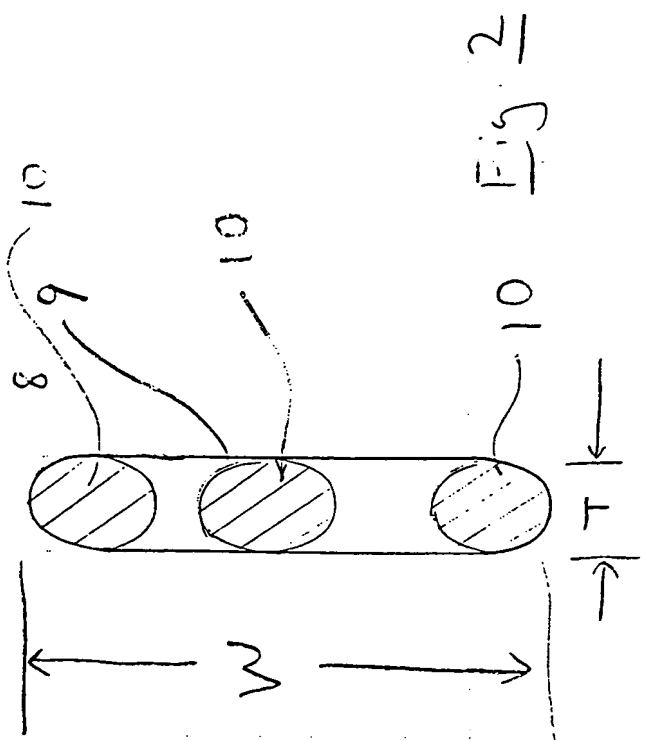
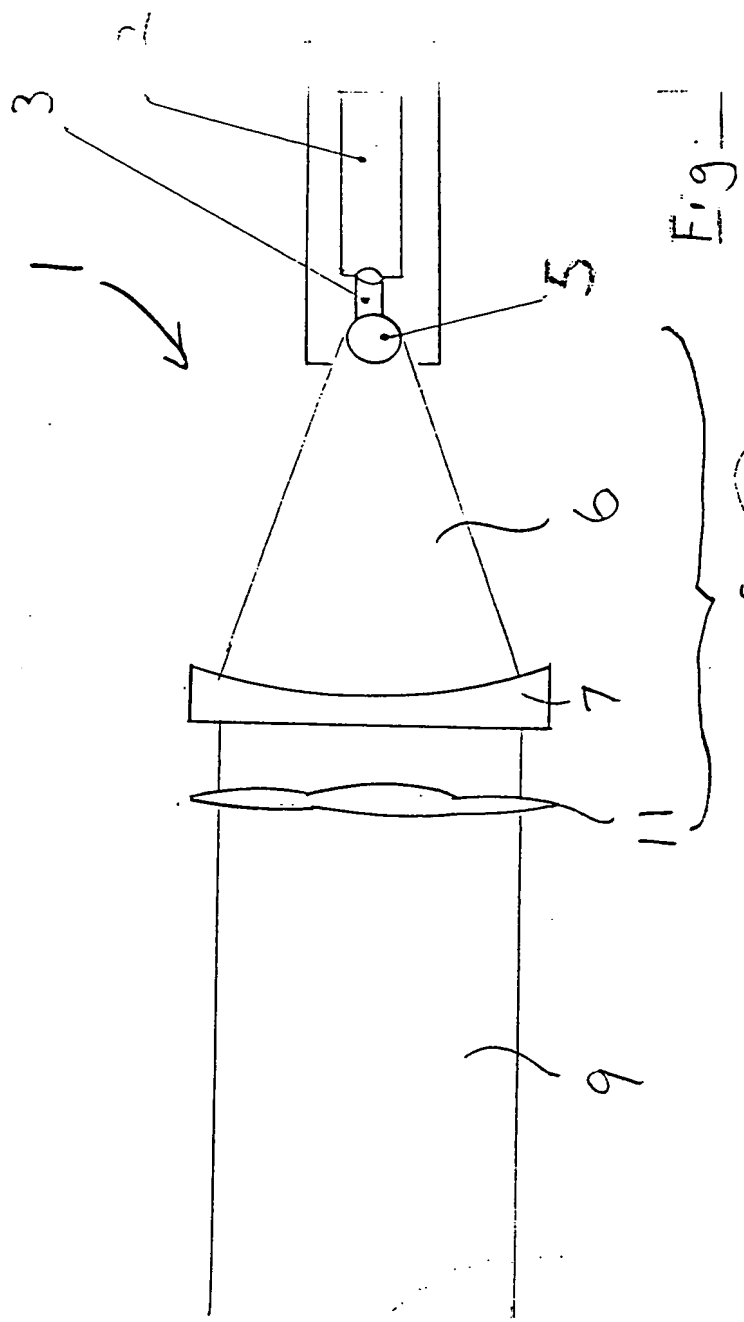
The use of the cylindrical lens 37 in the light receiving means 22 allows it to be set at a height that can accommodate the shortest blade 30 and it will accept any blade, for example up to 50 mm deeper.

the blade has an excessive depth) and the laser emitting means 1 is adjusted vertically to suit the blade 30. Because of this overall design, the adjusting for varying blades and alignment of both ends is very easy in this vertical plane. This
5 also helps with any vibration (ramifications of this previously described) in the vertical plane as well.

DATED this 5th day of May, 1999.

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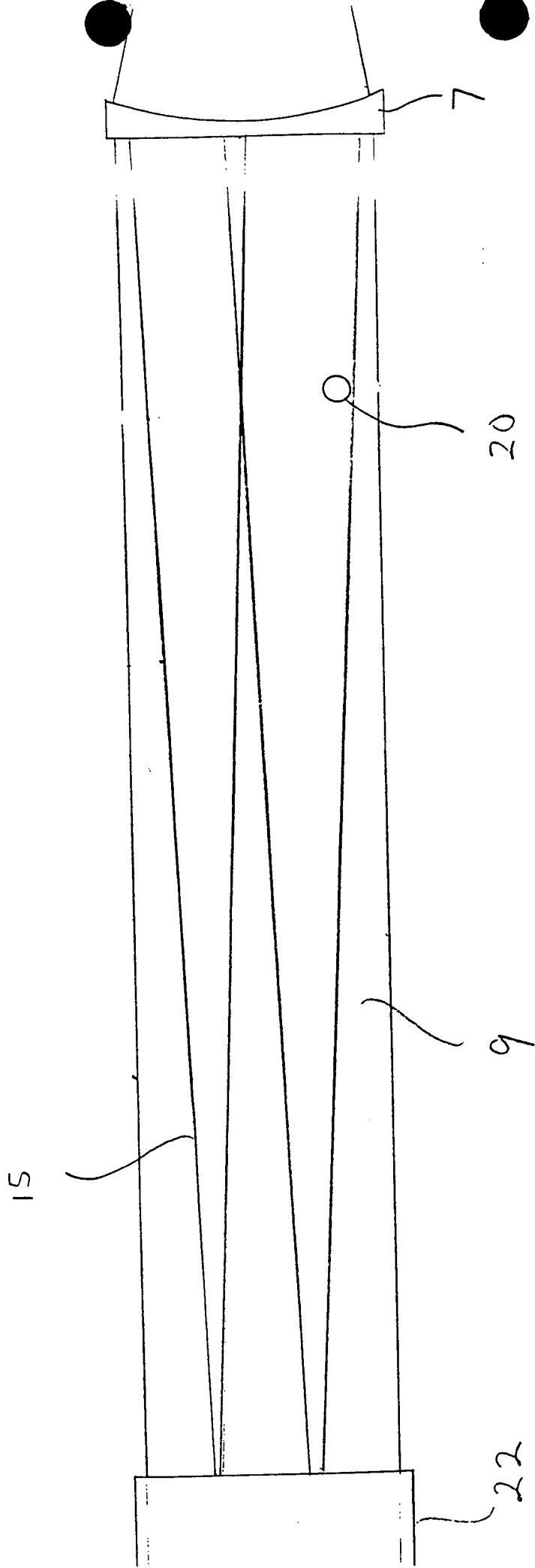


Fig. 3

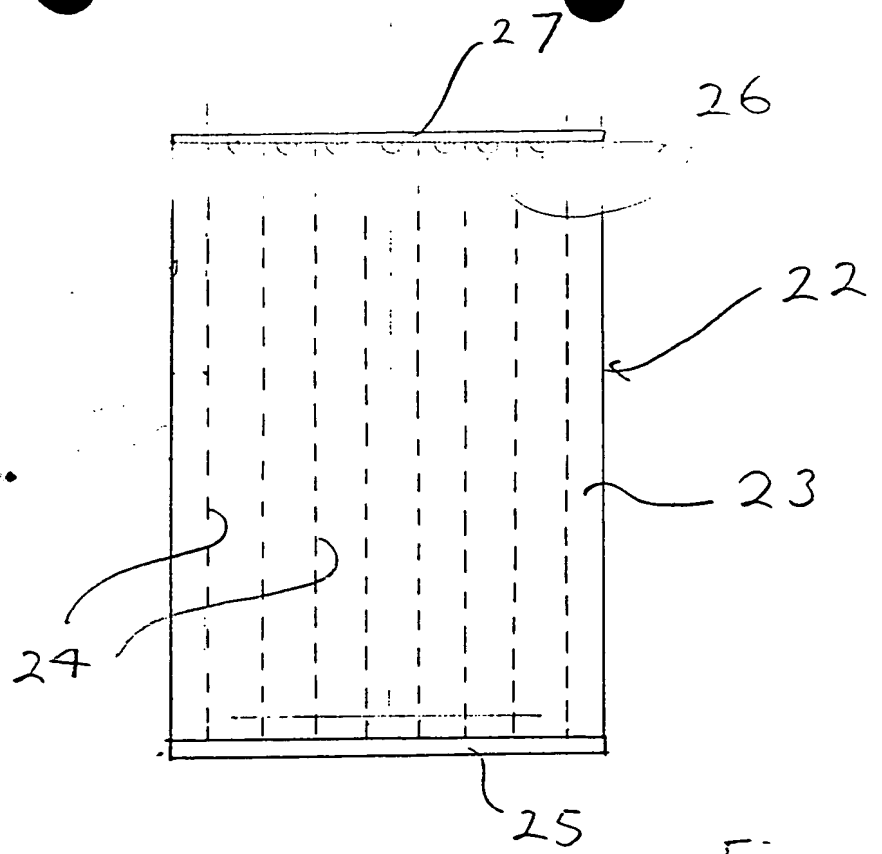


Fig. 4

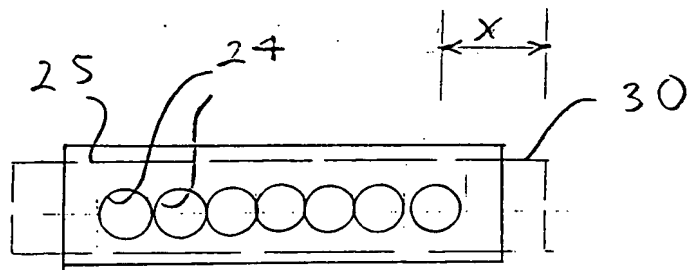


Fig. 5

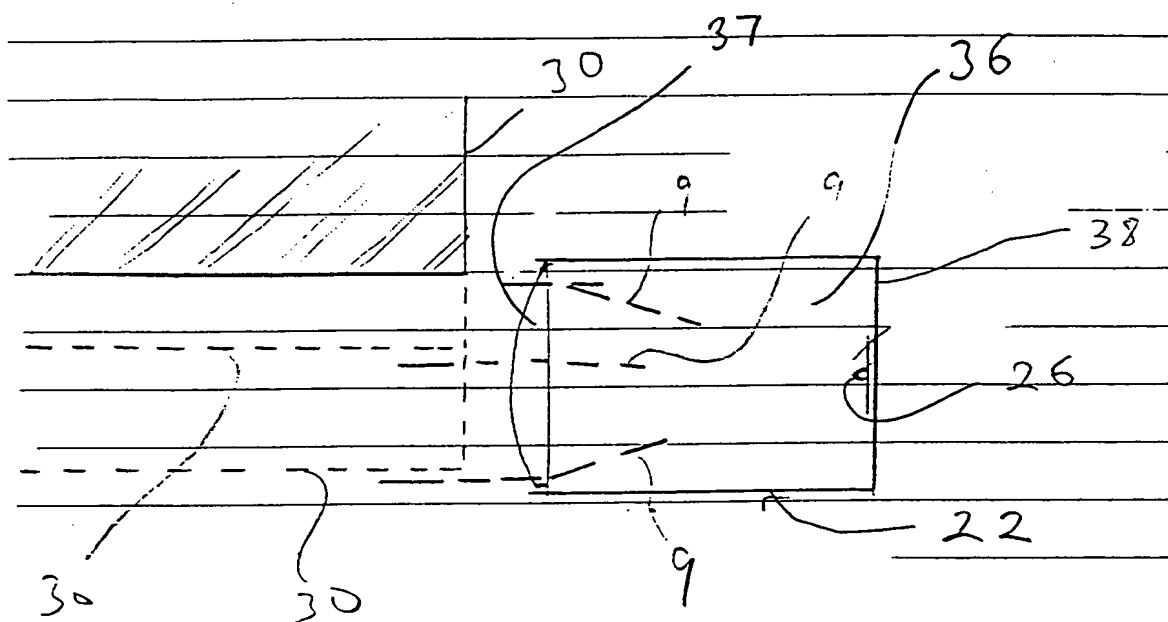


Fig. 6

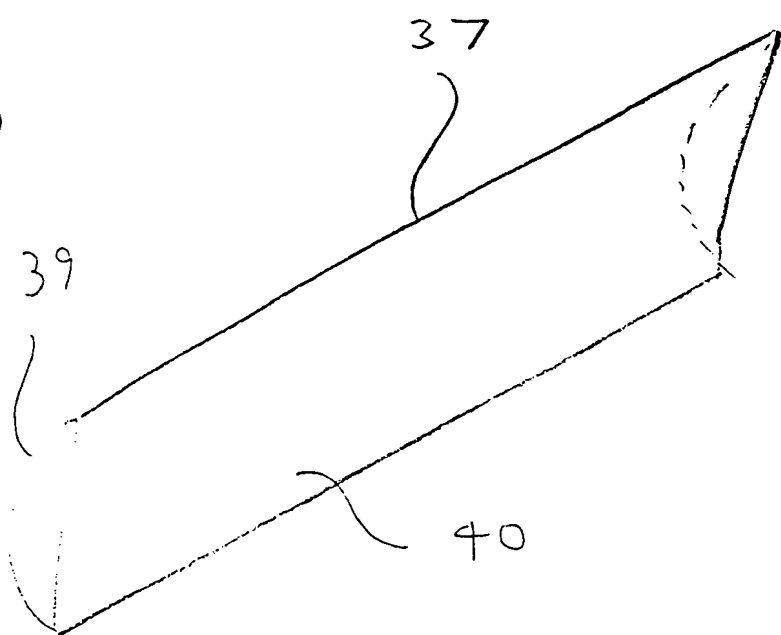


Fig. 7

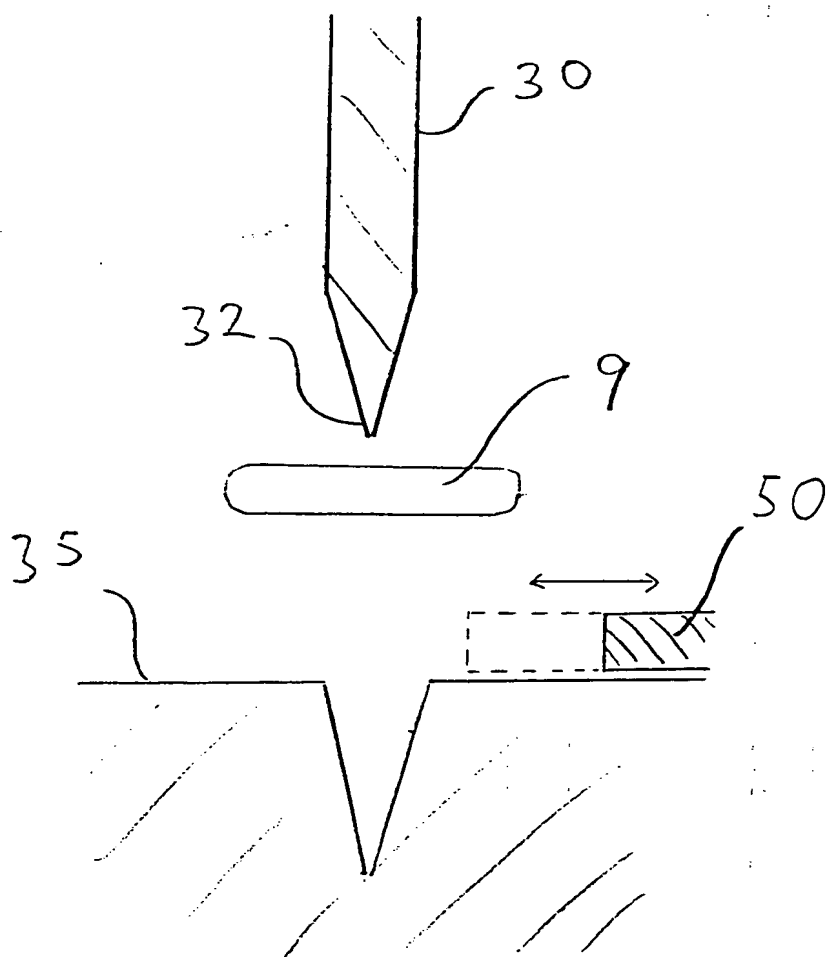


Fig. 8

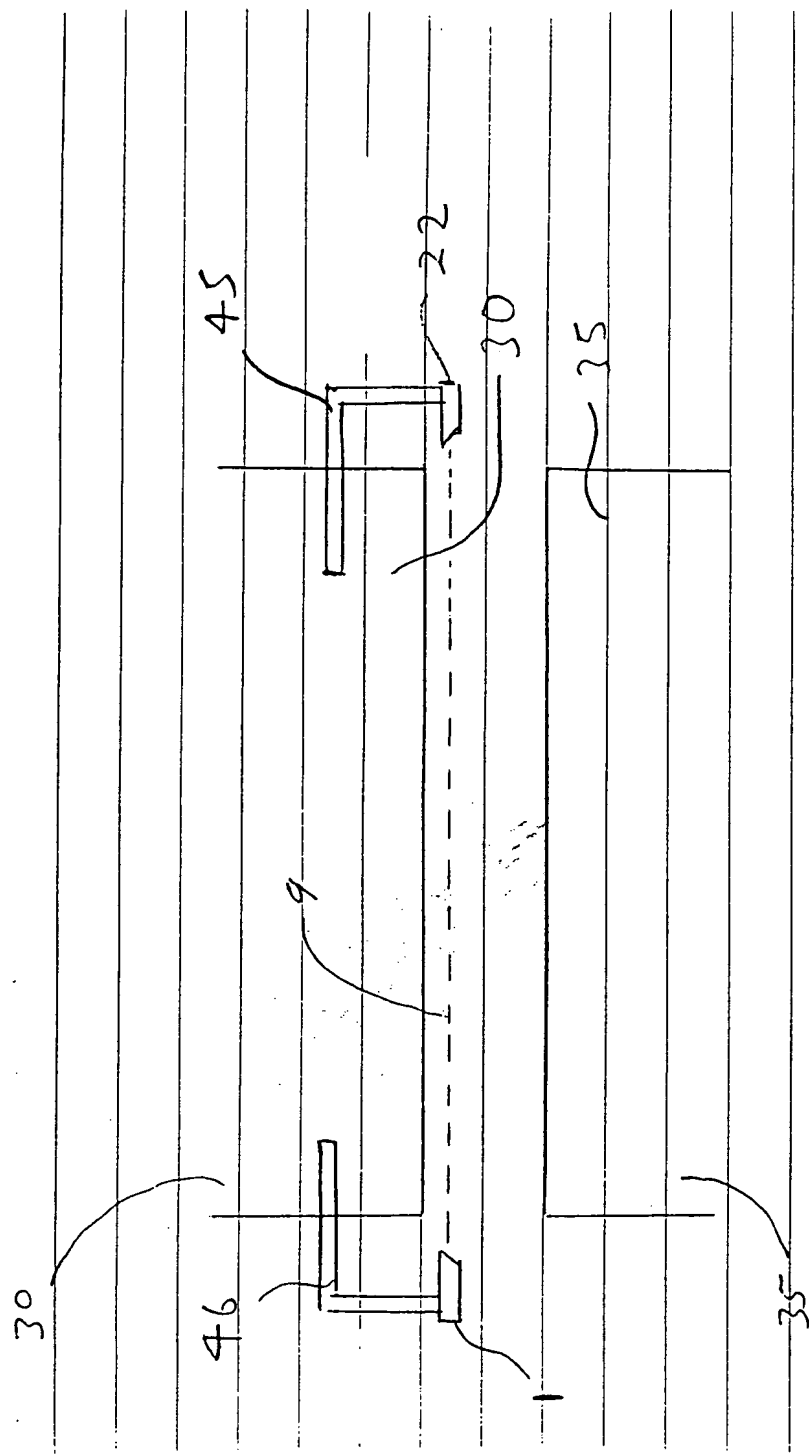


Fig. 9